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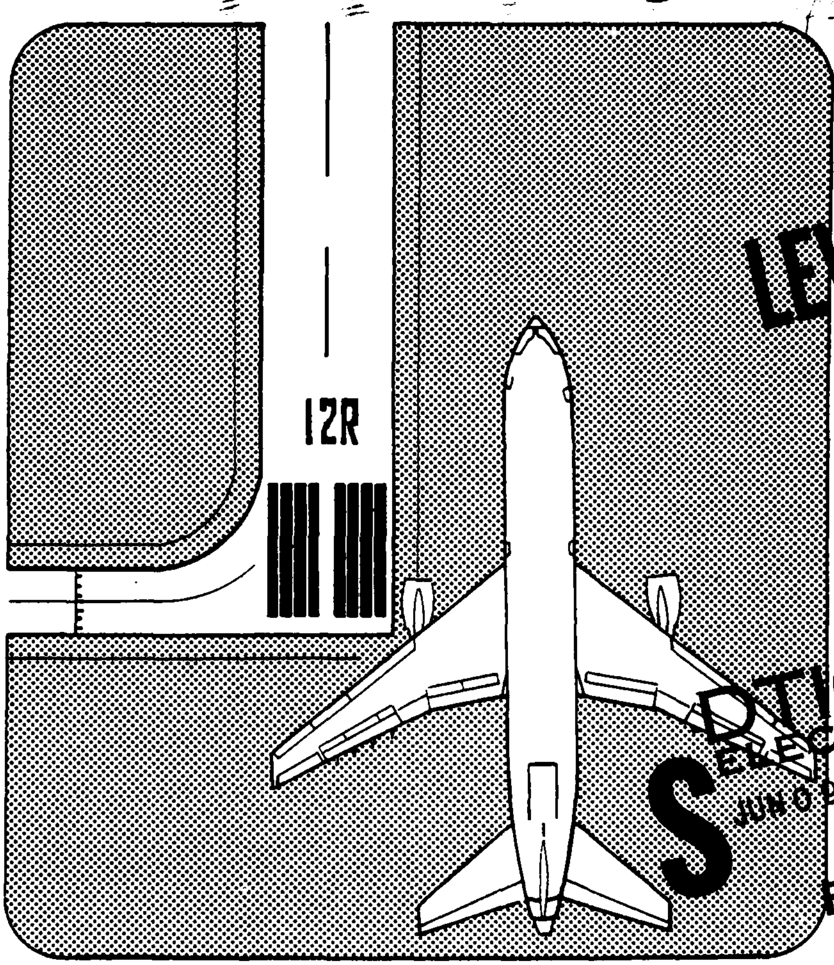
LAMBERT-ST. LOUIS INTERNATIONAL AIRPORT DATA PACKAGE ~~NO.~~ Number 6.

AIRPORT IMPROVEMENT TASK FORCE DELAY STUDIES



prepared for
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
under contract
DOT-FA77WA-3961

Peat, Marwick, Mitchell & Co.

AUGUST 1980

Peat, Marwick, Mitchell & Co.

P.O. Box 8007
San Francisco International Airport
San Francisco, California 94128

(415) 347-9521

August 26, 1980

Mr. Michael M. Scott, ATF-4
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Re: St. Louis Data Packages No. 6 and No. 7

Dear Mike:

Enclosed are twenty-five copies of Data Packages No. 6 and No. 7 for Lambert-St. Louis International Airport. Data Package No. 6 presents the improvement benefit descriptions and summarizes the results of the delay analyses. All the supporting data for Data Package No. 6 are presented in Data Package No. 7.

The St. Louis Task Force should review both data packages during the meeting scheduled for August 28, 1980.

Sincerely,

Steve

Stephen L. M. Hockaday
Manager

SLMH/db
Enclosure

cc: Mr. J. R. Dupree (ALG-312) (w/o enclosure)
Mr. M. J. Fischer (ACE-610)

LAMBERT-ST. LOUIS INTERNATIONAL AIRPORT

DATA PACKAGE NO. 6

Airport Improvement Task Force
Delay Studies

Prepared by

Peat, Marwick, Mitchell & Co.
San Francisco, California

August 1980

TABLES

EXHIBITS

PURPOSE

The purpose of Data Package No. 6 is to summarize the results of the delay analyses conducted for Lambert-St. Louis International Airport. In the delay analyses, eight potential improvement options that could be implemented to reduce aircraft delays were studied.

To conduct the delay analyses, a simulation model was used that reflects observed system operations. After the model was validated against real-world data on demand and delay, it was used to quantify the benefits of the delay reduction options identified by the Task Force. The results from the improvement experiments were then compared with the data from the baseline experiments, and the potential reductions in delay were assessed.

A second model, the annual delay model, was used to estimate the average annual delays that could be expected at the Airport under various existing (baseline) and future conditions (post-1985 and post-1990).

The information developed in the delay analyses can be used by the Task Force to identify the improvement options that have the greatest potential for reducing aircraft delays at the Airport. The Task Force can also use the information when it prepares the final Task Force report for the Airport.

BACKGROUND

In this section, the existing (baseline) conditions at Lambert-St. Louis International Airport are discussed.

Airfield Demand

Table 1 presents the forecast airfield demand used in the Task Force study. As indicated, total aircraft operations are forecast to increase from 336,178 in 1979 to 344,000 in the post-1985 period and 374,000 in the post-1990 period.

The forecast peak hour demand shown in Table 1 is estimated for each of the four classes of aircraft (A, B, C, and D), which are defined according to aircraft takeoff weights and performance characteristics. Table 2 gives the takeoff weights and examples of typical aircraft in each class.

Table 1

FORECASTS OF AIRCRAFT OPERATIONS
Lambert-St. Louis International Airport

	Actual 1979	Post-1985	Post-1990
Annual forecasts			
Air carrier	202,845	220,000	250,000
Air taxi	34,834	27,000[a]	32,000[a]
General aviation	90,797	85,000[a]	80,000[a]
Military	7,702	12,000	12,000
Total	336,178	344,000	374,000
Peak hour forecasts (VFR)[b]			
Aircraft class			
A	6	4	3
B	22	21	21
C	51	47	47
D	2	13	22
Total	81	85	93

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a. Forecast data for air taxi includes only scheduled commuter service. Nonscheduled air taxi forecasts are included in general aviation forecasts.

b. Average day, peak month (August). The term VFR refers to visual flight rule weather conditions.

Table 2

AIRCRAFT CLASSIFICATION

Aircraft class	Takeoff weight (pounds)	Types of aircraft
A	12,500 or less	Small single-engine aircraft (such as Piper PA-23, Cessna C-180, Cessna C-207)
B	12,500 or less and some Lear-jets	Small twin-engine aircraft (such as Piper PA-31, Beech BE-55, Cessna C-310, Learjet LR-25)
C	12,500 to 300,000	Large aircraft (such as Convair CV-580, B-707-120, B-727, DC-9, B-737, B-757)
D	300,000 or more	Heavy aircraft (such as B-747, B-767, DC-10, L-1011, DC-8-62, B-707-300)

The mix of these classes of aircraft is also crucial to the determination of future delays on the airfield. Table 1 shows that the heavy aircraft (Class D) are forecast to increase dramatically in the peak hour--from 2 operations per hour in 1979 to 22 per hour in the post-1990 period.

Exhibit 1 displays the hourly variation in traffic.

Runway Use Configurations

Exhibit 2 depicts the existing airfield layout with planned development at Lambert-St. Louis International Airport. Table 3 lists the runway use configurations at the Airport and presents the average annual percentage utilization of these configurations in different weather conditions. As indicated, the use of the parallel runways (12L and 12R and 30L and 30R) is the predominant use pattern during all types of weather.

Runway Capacity

Runway capacity is the maximum number of aircraft operations (landings or takeoffs) that can be processed in an hour under specific conditions of:

- Ceiling and visibility conditions
- Air traffic control procedures
- Runway layout and use
- Aircraft mix (types of aircraft)
- Percentage of arrivals

Many factors limit runway capacity at the Airport, including:

- Proximity of parallel runway sets (ILS* approaches to parallel runways are not independent.)
- Weather, wind, and visibility conditions sometimes limit approaches to one direction.
- Wake turbulence and the mix of heavy aircraft

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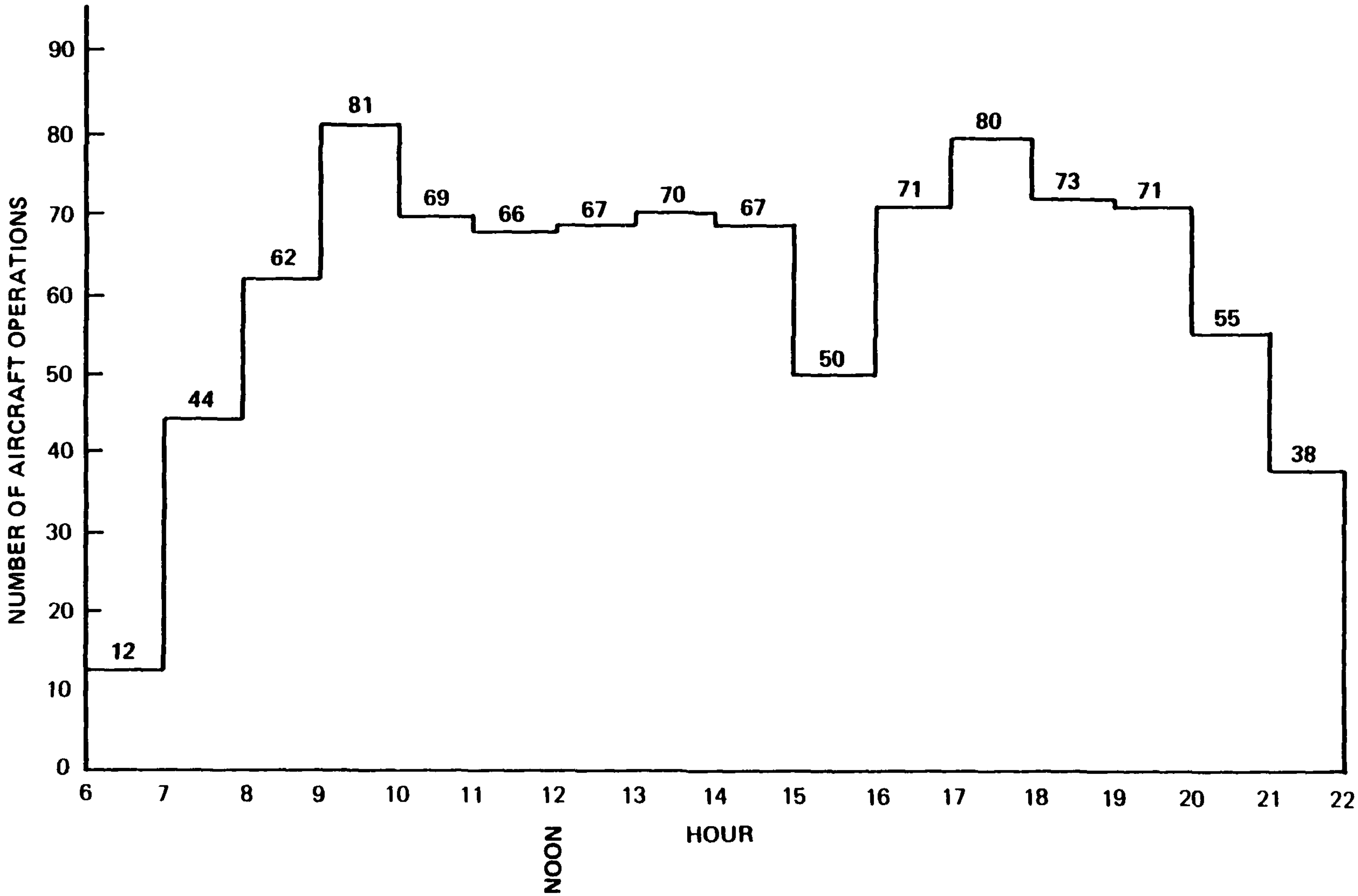
*Instrument landing system

Exhibit 1

HOURLY VARIATION OF TRAFFIC
LAMBERT–ST. LOUIS INTERNATIONAL AIRPORT
Average day, Peak month, 1979



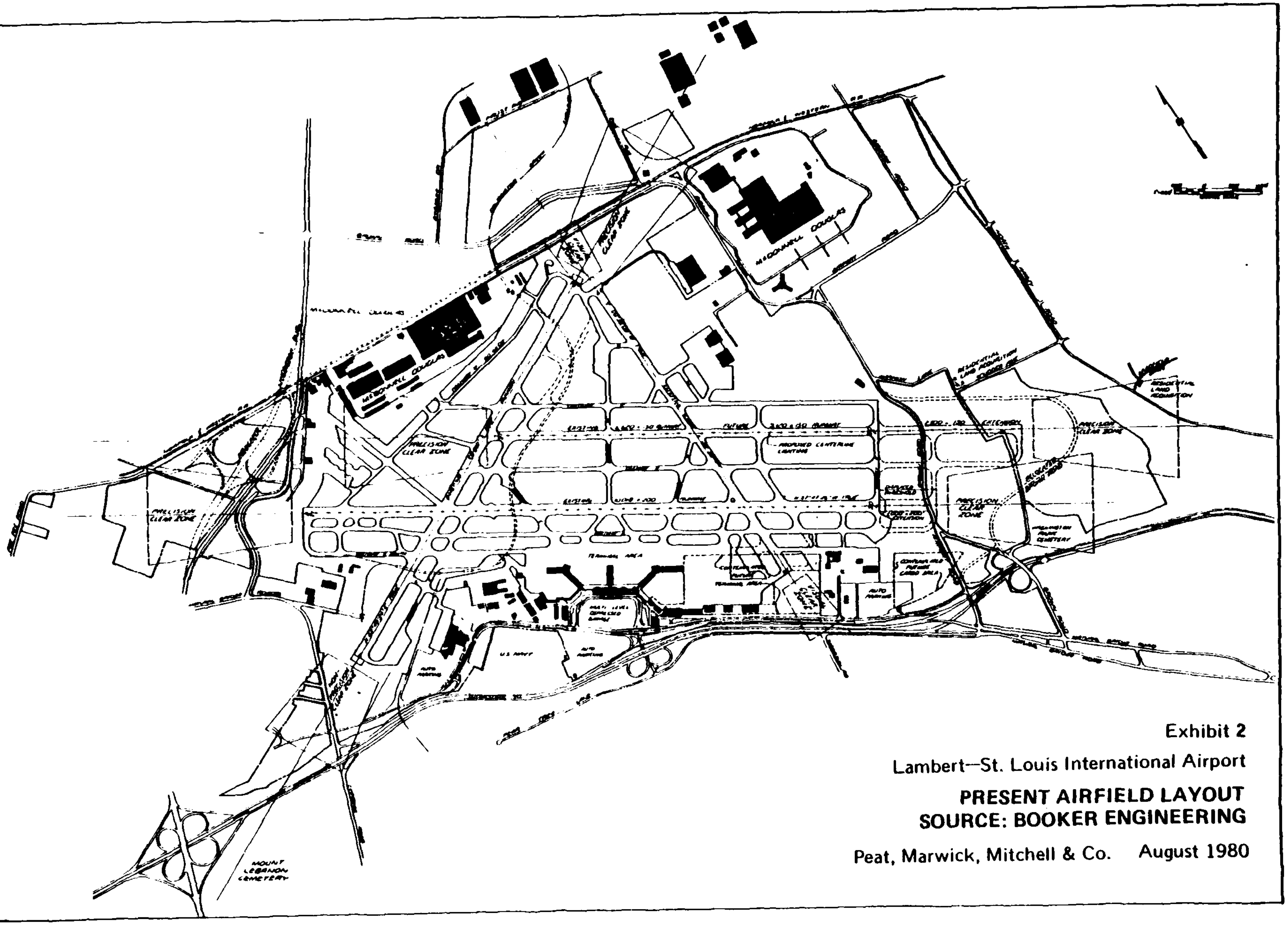


Exhibit 2

Lambert—St. Louis International Airport

PRESENT AIRFIELD LAYOUT
SOURCE: BOOKER ENGINEERING

Peat, Marwick, Mitchell & Co. August 1980

Table 3

RUNWAY USE CONFIGURATIONS
Lambert-St. Louis International Airport

	Runway use		Percentage use (1978)			
Number	Arrival	Departure	VFR	IFR1	IFR2 and 3	Total
1	12R, 12L	12R, 12L	45.0	41.8	23.9	43.7
2	30R, 30L	30R, 30L	53.0	56.7	74.1	54.3
3	30R, 30L, 24	30R, 30L	0.7	0.5	0.3	0.6
4	12R, 12L	12R, 12L, 6	0.3	0.2	0.2	0.3
5	24	24	0.7	0.6	1.4	0.8
6	12R, 12L, 17	12R, 12L	0.3	0.2	0.1	0.3
Average/Total			91.0	3.6	5.4	100.0

Weather definitions

Weather	Visibility/ceiling
VFR*	Better than 3 miles and 1,000 feet
IFR1**	Between 2 miles and 800 feet and 3 miles and 1,000 feet
IFR2 and IFR3	Below 2 miles and/or 800 feet but above operating minimums

*VFR = visual flight rule
**IFR = instrument flight rule

- Requirement of en route separation (Aircraft must be spaced 5 miles apart when Air Route Traffic Control Center assumes control. This requirement often causes departure delays.)
- Runway maintenance and construction
- Runway and apron congestion
- Placement of general aviation areas
- Effect of Lambert operations on neighboring airports

Table 4 presents runway capacity estimates for 1979.

AIRSPACE CONSTRAINTS

The airspace constraints that affect the timing of landings and takeoffs at Lambert-St. Louis International Airport were not considered in this data package. This subject has been studied by the Air Traffic Delay Study Group and its findings are presented in a separate report.* It should be noted, however, that this study group found that 80% of the delays at the Airport develop because of airspace constraints.

The results of the airfield delay study presented in this Data Package No. 6 do not reflect the current airspace constraints on capacity and delay at the Airport. Rather, they are intended to show what would happen in the absence of airspace constraints.

AIRFIELD DELAYS

Airfield delay is the additional travel time, caused by airfield congestion, taken by aircraft that are landing and taking off at an airport. Airfield delay depends on:

- Airfield physical characteristics
- Air traffic control procedures
- Aircraft operational characteristics

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*St. Louis Tower and Kansas City Center, Federal Aviation Administration, Central Region, "Air Traffic Delay Study Group Report," April 1980.

Table 4

RUNWAY CAPACITY
Lambert-St. Louis International Airport
1979[a]

	Runway use[b]		Hourly capacity (operations per hour)		
Number	Arrival	Departure	VFR1	IFR1	IFR2 and 3
1	12R, 12L	12R, 12L	112	63	65
2	30R, 30L	30R, 30L	112	63	65
3	30R, 30L, 24	30R, 30L	138	93	n.a.
4	12R, 12L	12R, 12L, 6	112	63	65
5	24	24	55	53	47
6	12R, 12L, 17	12R, 12L	116	68	n.a.

a. Assumes aircraft mix for conditions with no strike at Ozark Air Lines.
b. Runway use shown for VFR conditions.

- Airfield demand
- Weather

Airfield delays are expressed in minutes per aircraft operation.

Congestion results whenever the volume of aircraft operations at an airport approaches or exceeds airfield capacity. Aircraft delays during congested periods are very high.

Simulation Results

The airfield simulation model was used to determine the existing level of aircraft delays at Lambert-St. Louis International Airport. The results are summarized in Table 5.

As shown, the peak hour delay in visual flight rule (VFR) conditions is about 0.5 minute per aircraft for arrivals and about 1.3 to 2.5 minutes per aircraft for departures, for all runway uses studied. The average daily delay in VFR conditions is about 0.3 minute per aircraft for arrivals and 0.6 to 1.3 minutes per aircraft for departures. (Again note that these delays do not take into account airspace constraints.)

The aircraft delays are significantly higher in instrument flight rule (IFR) conditions when only the parallel runways are in use; the arrival delays are about 30 minutes per aircraft during the peak hour and about 17 minutes per aircraft for the day. The departure delays range from 2 to 13 minutes per aircraft (depending on ceiling and visibility) in the peak hour, and from 2 to 7 minutes per aircraft for the day.

The delays are very high when wind conditions force the use of Runway 24 only. In this case, peak delays increase to 55 minutes per aircraft for arrivals and 21 minutes per aircraft for departures. Corresponding values for the day are 19.3 minutes per aircraft for arrivals and 16.3 minutes per aircraft for departures.

When wind conditions allow Runway 24 to be used for arrivals in conjunction with the use of parallel Runways 30L and 30R in IFR1 weather, the arrival delays decrease significantly to 1.6 minutes per aircraft during the peak hour and 1.3 minutes per aircraft for the day.

In summary, the aircraft delays at Lambert-St. Louis International Airport are relatively low <u>except</u> when weather conditions do not permit two simultaneous arrival streams.

Table 5

SUMMARY OF EXISTING LEVEL OF AIRCRAFT DELAYS
Lambert-St. Louis International Airport

Experiment No.	Arrival runways	Departure runways	Weather conditions	Runway delays: Peak (minutes) Arrival	Runway delays: Peak (minutes) Departure	Runway delays: Average daily (minutes) Arrival	Runway delays: Average daily (minutes) Departure
1	12L, 12R	12L, 12R	VFR	0.5	2.4	0.3	1.2
2	12L, 12R	12L, 12R	IFR1	41.9	2.3	16.7	2.2
3	12L, 12R	12L, 12R	IFR2 and 3	26.6	12.9	8.4	6.8
4	30L, 30R	30L, 30R	VFR	0.6	2.5	0.3	1.2
5	30L, 30R	30L, 30R	IFR1	43.0	2.4	17.3	2.1
6	30L, 30R	30L, 30R	IFR2 and 3	28.4	13.9	9.5	7.6
7A	24, 30L, 30R	30L, 30R	VFR	0.7	2.0	0.3	1.2
7	24, 30L, 30R	30L, 30R	IFR1	1.6	5.0	1.3	2.6
8	12L, 12R	6, 12L, 12R	VFR	0.6	1.3	0.4	0.6
9	12L, 12R	6, 12L, 12R	IFR1	41.8	0.4	16.7	0.3
10	12L, 12R	6, 12L, 12R	IFR2 and 3	8.1	3.6	3.8	1.6
11	24	24	IFR2 and 3	55.2	20.8	19.3	16.3
12	17, 12L, 12R	12L, 12R	VFR	0.5	2.4	0.3	1.3
13	17, 12L, 12R	12L, 12R	IFR1	31.8	2.6	11.8	2.3

Annual Delay Results

As stated previously, the annual delay model was used to estimate the average annual delays expected at the Airport given the various runway uses and weather conditions discussed in the Background section.

Table 6 illustrates the increases in average annual delay that are estimated to occur in the future if the 1979 airfield remains in the future.

Current delays are relatively low (less than 1 minute per aircraft), but delays are expected to increase to about 6.5 minutes for every operation in the post-1990 period as the demand and the proportion of heavy aircraft in the mix increase. At an assumed delay cost of $20 per minute, the annual delay costs would amount to $5.7 million in 1979, $11.3 million in the post-1985 period, and $48.3 million in the post-1990 period.

Effect of Noise Abatement Procedure On Departure Delays

The effect of the noise abatement procedure on aircraft delays at the Airport was also studied using both the airfield simulation model and the annual delay model. This study does not judge the appropriateness of the noise abatement procedure; it is only prepared to illustrate the tradeoffs between environmental and operational concerns.

Briefly, the noise abatement procedure used in the study is to require that departures follow the same flight track until they are at an altitude of 2,000 feet MSL* before turning. The procedure is relaxed during the departure peak (1400 to 1500 hours) to allow aircraft to turn as soon as feasible.

The simulation results for operations on Runways 12L and 12R are shown in Table 7.

The results indicate that the noise abatement procedure would increase the average peak hour departure delays from 2.0 minutes to 9.3 minutes and the average daily departure delays from 1.2 minutes to 6.4 minutes. If the noise abatement procedure is applied to Runway 12R only, the increase in departure delays would be much smaller.

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*Mean sea level.

Table 6

ESTIMATED AVERAGE DELAYS--1979 AIRFIELD
Lambert-St. Louis International Airport

Study period	Demand	ATC scenario	Airfield	Annual delay: Average (minutes per aircraft)	Annual delay: Total (hours)
1979	344,600[a]	1979	Existing	0.8	4,722
post-1985	344,000	1979	Existing	1.6	9,399
post-1990	374,000	1979	Existing	6.5	40,273

a. Assumes no strike at Ozark Air Lines.

Table 7

NOISE ABATEMENT SIMULATION EXPERIMENT
RESULTS FOR RUNWAYS 12L and 12R
Lambert-St. Louis International Airport

		Average delays			
		Peak (minutes)		Daily (minutes)	
Scenario	Description	Arrival	Departure	Arrival	Departure
1	no noise abatement	0.5	2.0	0.3	1.2
2	no noise abatement for Runway 12L noise abatement for Runway 12R	0.5	3.1	0.3	1.8
3	noise abatement for both Runways 12L and 12R	0.5	9.3	0.3	6.4

The effect of the noise abatement procedure on annual delays was also analyzed. Without the procedure, the average annual delay is about 0.8 minute per aircraft in 1979. With the noise abatement procedure, the annual delay averages 1.0 minute per aircraft. This increase is equivalent to about $1.2 million in additional delay costs to aircraft.

The increase in average annual aircraft delays resulting from the noise abatement procedure would be 0.5 minute per aircraft in the post-1985 period and 1.3 minutes per aircraft in the post-1990 period. In terms of additional annual delay costs, this increase represents about $3.0 million in the post-1985 period and $9.7 million in the post-1990 period.

IMPROVEMENT OPTIONS

Various airfield system improvements, ranging from changes in air traffic control procedures to changes in physical facilities and operations, could increase airfield capacity and thus reduce delays. The Task Force identified eight improvement options that should be studied in this data package to determine how each improvement option would reduce aircraft delays. In the text that follows, each improvement is briefly described and the delay reductions possible under each option are discussed. Some of these improvement options are committed or planned for implementation. The analyses of these improvements are included here at the request of the Task Force to estimate the benefits of the improvements.

Improvement Option 1--Complete Airfield Development Program

The airfield development program currently nearing completion consists of a 2,500-foot extension of Runway 12L-30R to the east, plus numerous improvements to existing taxiways and construction of new taxiways. In addition, the use of Runway 17-35 south of its intersection with Runway 12L-30R will be discontinued in the future.

The extension of Runway 12L-30R will provide a total runway length of 9,120 feet, thus permitting it to be used by all categories of air carrier aircraft. Under VFR weather conditions, dual simultaneous arrival and departure streams of all categories of aircraft can occur.

From the annual delay experiments, it was estimated that this option will reduce the total delays 1,900 hours per year (or 0.3 minute per aircraft) in the post-1985 period and 12,700 hours per year (or 2.1 minutes per aircraft) in the post-1990 period. This reduction in delays is equivalent to $2.3 million per year in the post-1985 period and $15.3 million in the post-1990 period.

Simulation experiments were performed to study the effects of the airfield development program on peak hour and daily delays. The delays listed in Table 8 were obtained for VFR weather using post-1985 demand.

As shown, VFR delays will not be significantly affected by the airfield development program, at least with the forecast 1985 demand and mix because a significant proportion of the traffic will be able to use the existing length of Runway 12L-30R. Consequently, the use of the parallel runways will be fairly balanced.

For IFR1 weather, three runway uses were studied. The delays are summarized in Table 9.

The primary effect of the airfield development program will be that arrivals and departures can be assigned on separate runways, thereby reducing IFR departure delays. For example, when using either parallel Runways 12L, 12R, or 30L, 30R, present ATC procedures do not permit two independent arrival streams. Consequently, the extension of Runway 12L-30R does not reduce arrival delays.

With the existing airfield, runway length considerations would require the use of Runway 12R-30L to be used by many of the departing aircraft in addition to the arriving aircraft. After the airfield development program is completed, it will be possible to have arrivals land on Runway 12R-30L and departures take off (independent of the arrivals) on Runway 12L-30R. Therefore, the peak departure delays can be reduced from 5 minutes to less than half a minute, and the average daily departure delays can decrease from 3 minutes to half a minute.

The most significant contribution of the airfield development program to delay reductions will be when arrivals can use Runway 24 in addition to Runways 30L and 30R. In this case, both arrival and departure delays will be reduced substantially because more departures can be assigned to use Runway 30R. With the existing airfield, many arrivals and departures require the use of Runway 30L.

Improvement Option 2--Use Localizer Directional Aid (LDA)

This improvement would involve the installation of an instrument landing system (ILS) localizer antenna north of the Airport with its beam radiating parallel to the localizer beam for Runway 12R. Under certain conditions of IFR weather, aircraft could approach the airport using the offset localizer beam

Table 8

EFFECTS OF AIRFIELD DEVELOPMENT PROGRAM ON VFR AIRCRAFT DELAYS
Lambert-St. Louis International Airport

Experiment No.	Description	Runway use		Runway delays			
				Peak hour (minutes)		Average daily (minutes)	
		Arrival	Departure	Arrival	Departure	Arrival	Departure
26	Baseline	12L, 12R	12L, 12R	1.7	4.4	0.9	2.1
35	Airfield Development	12L, 12R	12L, 12R	1.3	4.1	0.8	2.2
32A	Baseline	24, 30L, 30R	30L, 30R	2.2	4.6	0.8	2.3
39A	Airfield Development	24, 30L, 30R	30L, 30R	1.3	5.4	0.7	2.4

Table 9

EFFECTS OF AIRFIELD DEVELOPMENT PROGRAM ON IFR1 AIRCRAFT DELAYS
Lambert-St. Louis International Airport

Experiment No.	Description	Runway use		Runway delays			
				Peak hour (minutes)		Average daily (minutes)	
		Arrival	Departure	Arrival	Departure	Arrival	Departure
27	Baseline	12L, 12R	12L, 12R	54.8	5.1	25.7	3.0
36	Airfield Development	12L, 12R	12L, 12R	59.3	0.3	25.8	0.5
30	Baseline	30L, 30R	30L, 30R	51.7	5.4	25.1	3.1
38	Airfield Development	30L, 30R	30L, 30R	60.2	0.4	26.1	0.5
32	Baseline	24, 30L, 30R	30L, 30R	14.8	11.8	4.0	5.0
39	Airfield Development	24, 30L, 30R	30L, 30R	3.7	2.7	2.0	1.9

until they broke out under the cloud cover, and then the aircraft would turn to land on Runway 12L. This landing procedure, in effect, would provide dual arrival streams that would significantly increase the IFR capacity at the Airport.

It was estimated that the implementation of this improvement option would reduce annual delays 730 hours in the post-1985 period and 2,275 hours in the post-1990 period. This reduction in delay is equivalent to $876,000 per year in the post-1985 period and $2.7 million per year in the post-1990 period.

Analysis of the changes in post-1985 peak hour and daily delays resulting from this improvement option is summarized in Table 10.

As shown, implementation of the LDA approach (in the cases where arrivals land on the parallel runways only) would reduce arrival delays dramatically, but would slightly increase departure delays. Arrival delays would decrease because the Airport would have dual arrival streams with the LDA approach. Consequently, delay benefits are much less when Runway 24 is also available for arrivals.

Similar observations can be made of the post-1990 analysis results, which are given in Table 11.

Improvement Option 3--Use Runways 6-24, 12L-30R, and 12R-30L Simultaneously

With Runway 12L-30R extended to 9,120 feet (Improvement Option 1), all categories of air carrier aircraft expected to be scheduled to the Airport in the future could use that runway. When wind and weather conditions permit the use of Runways 6-24, 12L-30R, and 12R-30L simultaneously, the capacity of this three-runway use pattern is substantially higher than that of the parallel runways alone.

For example, in the west flow configuration, Runways 24 and 30R could be used by arrival aircraft and Runway 30L could be used for aircraft departures.

This procedure is especially beneficial in IFR1 conditions and during periods when aircraft arrivals are greater than departures, because this procedure provides essentially two independent arrival streams. Historical data on runway use as shown in Table 3 indicate that (1) the use of parallel Runways 12L-30R and 12R-30L occurs 98% of the time; (2) the use of Runway 24 in conjunction with Runways 30L and 30R occurs only 0.6% of the time; and (3) the use of Runway 6 in conjunction with Runways 12L and 12R occurs only 0.3% of the time. An analysis of wind data

Table 10

EFFECTS OF LDA APPROACH ON AIRCRAFT DELAYS
(Post-1985)
Lambert-St. Louis International Airport

Experiment No.	Description	Runway use		Runway delays: Peak hour (minutes)		Runway delays: Average daily (minutes)	
		Arrival	Departure	Arrival	Departure	Arrival	Departure
36	IFR1 Baseline	12L, 12R	12L, 12R	59.3	0.3	25.8	0.5
41	LDA	12L, 12R	12L, 12R	1.2	7.2	1.2	2.8
40	IFR1 Baseline	12L, 12R	6, 12L, 12R	62.4	0.2	26.5	0.3
43	LDA	12L, 12R	6, 12L, 12R	2.5	1.3	1.3	0.7
39	IFR1 Baseline	24, 30L, 30R	30L, 30R	3.7	2.7	2.0	1.9
42	LDA	24, 30L, 30R	30L, 30R	2.5	3.9	1.0	2.3

Table 11

EFFECTS OF LDA APPROACH ON AIRCRAFT DELAYS
(Post-1990)
Lambert-St. Louis International Airport

Experiment No.	Description	Runway use		Runway delays			
				Peak hour (minutes)		Average daily (minutes)	
		Arrival	Departure	Arrival	Departure	Arrival	Departure
52	IFR1 Baseline	12L, 12R	12L, 12R	100+	0.5	60.6	0.8
60	LDA	12L, 12R	12L, 12R	5.9	15.0	2.6	5.6
58	IFR1 Baseline	12L, 12R	6, 12L, 12R	100+	0.3	59.7	0.3
62	LDA	12L, 12R	6, 12L, 12R	5.2	2.5	2.4	1.3
57	IFR1 Baseline	24, 30L, 30R	30L, 30R	12.1	6.4	5.3	2.7
61	LDA	24, 30L, 30R	30L, 30R	4.1	11.1	2.1	4.3

reveals that Runways 6-24, 12L-30R, and 12R-30L could be used up to about 90% of the time. Therefore, if the pattern of runway use was changed from a predominantly two-runway configuration today to a predominantly three-runway configuration in the future, annual aircraft delays could be expected to decrease significantly.

Results of the annual delay experiments show that annual aircraft delays would be reduced 1,400 hours per year in the post-1985 period and 15,300 hours per year in the post-1990 period. This reduction represents a savings in annual delay costs of $1.6 million and $18.4 million in the post-1985 and post-1990 periods, respectively.

Improvement Option 4--Increase Use of Heavy Jets

In this improvement option, the airlines would increase their use of heavy jet (widebody) aircraft, especially the L-1011 and DC-10. The airlines could then enplane more passengers per flight, on the average, and fewer aircraft operations would be needed to carry a given number of passengers. The use of more heavy jet aircraft would not necessarily result in lower aircraft delays because the average separation between aircraft would increase to avoid wake turbulence interactions. As a consequence, both demand and runway capacity would decrease. The net change in delay is determined by the relative magnitude of reduction between demand and capacity.

For the post-1985 period, total annual aircraft operations would be reduced from 344,000 to 336,000 (a decrease of 8,000 operations). The percentage of heavy jets in the aircraft mix would increase from about 13% to 16%. Average annual delays to aircraft would increase by about 0.2 minute per aircraft. This increase represents an additional annual delay cost of $1.3 million.

For the post-1990 period, total annual aircraft operations would be reduced from 374,000 to 339,000 (a decrease of 35,000 operations). The percentage of heavy jets in the aircraft mix would increase from about 20% to 31%. Average annual delays to aircraft would increase by 0.3 minute per aircraft. However, total aircraft delays would be reduced about 900 hours because of the reduction in demand. This decrease would represent a savings in aircraft delay costs of about $1 million per year.

The effects of increased heavy jet operations on peak and daily delays were studied in two simulation experiments. They are summarized in Table 12. As shown, the peak and daily delays would increase slightly as the number of heavy jet operations in the mix increase.

Table 12

EFFECTS OF INCREASED HEAVY JET OPERATIONS ON PEAK AND DAILY DELAYS
Lambert-St. Louis International Airport

Experiment No.	Description	Runway use		Runway delays: Peak hour (minutes)		Runway delays: Average daily (minutes)	
		Arrival	Departure	Arrival	Departure	Arrival	Departure
35	post-1985 Baseline	12L, 12R	12L, 12R	1.3	4.1	0.8	2.2
35A	post-1985 Increase Heavy Jets	12L, 12R	12L, 12R	1.3	4.7	0.9	2.1
51	post-1990 Baseline	12L, 12R	12L, 12R	4.5	6.4	1.8	3.1
51A	post-1990 Increase Heavy Jets	12L, 12R	12L, 12R	4.7	6.3	2.0	3.1

Improvement Option 5--Decrease General Aviation Activity

In this improvement option, the Airport could encourage general aviation aircraft to use satellite airports by adopting certain management policies (such as high landing fees), thereby reducing general aviation activity. The remaining general aviation activity may consist of only those that must use the Airport, such as aircraft that are carrying passengers who are transferring to air carrier flights. If the new management policies are focused on low-performance aircraft, airport capacity should increase and fewer aircraft delays should occur.

To illustrate the sensitivity of aircraft delays to a reduction in general aviation activity, three levels of reduction--25%, 50%, and 75% reduction in general aviation operations--were analyzed for the annual delay experiments. The annual general aviation operations would be as follows:

	Annual general aviation operations	
	Post-1985	Post-1990
Unconstrained	85,000	80,000
25% reduction	63,750	60,000
50% reduction	42,500	40,000
75% reduction	21,250	20,000

With a 25% reduction in general aviation activity, total aircraft delays would be reduced 1,900 hours per year in the post-1985 period and 10,200 hours per year in the post-1990 period. Savings in delay costs would be $2.3 million in the post-1985 period and $12.3 million in the post-1990 period. With a 50% reduction in general aviation activity, total aircraft delays would be reduced 3,400 hours per year (or $4.1 million) in the post-1985 period and 14,500 hours per year (or $17.4 million) in the post-1990 period. A 75% reduction in general aviation operations would result in annual delay reductions of 4,300 hours (or $5.2 million) in the post-1985 period, and 16,300 hours (or $19.6 million) in the post-1990 period.

Simulation experiments were also conducted to determine the effect of this improvement option on peak hour and daily delays. The experiments were performed for the runway use with arrivals and departures on both Runways 12L and 12R under VFR conditions. The Task Force recommended that only one reduction level (a 30% decrease for the post-1985 period and a 37% decrease for the post-1990 period) be investigated. The results are shown in Table 13.

Table 13

EFFECTS OF REDUCED GENERAL AVIATION ACTIVITY ON AIRCRAFT DELAYS
Lambert-St. Louis International Airport

Experiment No.	Description	Runway delays: Peak hour (minutes) Arrival	Runway delays: Peak hour (minutes) Departure	Runway delays: Average daily (minutes) Arrival	Runway delays: Average daily (minutes) Departure
35	Baseline	1.3	4.1	0.8	2.2
35B	Reduced general aviation	0.8	3.3	0.6	1.7
51	Baseline	4.5	6.4	1.8	3.1
51B	Reduced general aviation	2.4	4.7	1.2	2.5

Improvement Option 6--Implement Future Air Traffic Control (ATC) Systems

This improvement would involve the use of ATC systems that are being developed as part of the FAA Engineering and Development (E&D) Program. The ATC improvements associated with the E&D program are documented in FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Capacity/Delay."

For this study, it was assumed that (1) the ATC improvements would permit a 2.5-nautical mile separation of aircraft in arrival streams (3.5 nautical miles behind a heavy jet) and a 90-second separation of departing aircraft behind a heavy jet, and (2) these improvements would be in place in the post-1990 period.

Through the annual delay experiments performed in this study, it is estimated that reductions in total aircraft delays would be 9,200 hours per year, or a reduction in average annual delay of about 1.5 minutes per aircraft. This represents a savings in delay costs amounting to about $11 million per year.

The simulation experiment results shown in Table 14 indicate that the future ATC systems would reduce peak hour arrival delays and average daily arrival delays substantially in IFR1 weather.

Improvement Option 7--Relocate Midcoast Aviation

As future terminal expansion plans are implemented, pressures for the use of the land where Midcoast Aviation is now located will increase, and the Airport will have to consider relocating the facility. In addition to providing land for terminal expansion, the relocation of Midcoast Aviation may relieve some taxiway congestion and would separate general aviation from the heavy air carrier activity on the south side of the Airport.

Results of the simulation experiments performed to evaluate taxiway congestion are summarized in Table 15.

The relocation of Midcoast Aviation would have little effect on taxiway congestion for the case studied. Consequently, its major benefit would be to provide land for future terminal expansion.

Table 14

EFFECTS OF FUTURE ATC SYSTEM ON AIRCRAFT DELAYS
(Post-1990)
Lambert-St. Louis International Airport

Experiment No.	Description	Runway delays: Peak hour (minutes) Arrival	Runway delays: Peak hour (minutes) Departure	Runway delays: Average daily (minutes) Arrival	Runway delays: Average daily (minutes) Departure
52	IFR1 Baseline	100+	0.5	60.6	0.8
72	IFR1 Future ATC	57.1	0.5	21.8	0.7

Table 15

EFFECTS OF MIDCOAST AVIATION RELOCATION ON AIRCRAFT TRAVEL TIME
(Post-1990)
Lambert-St. Louis International Airport

Experiment No.	Description	Runway use		Travel time: Peak hour (minutes)		Travel time: Average daily (minutes)	
		Arrival	Departure	Arrival[a]	Departure[b]	Arrival[a]	Departure[b]
52	VFR Baseline	12L, 12R	12L, 12R	2.9	10.8	2.9	7.7
64	Midcoast relocation	12L, 12R	12L, 12R	2.9	10.6	3.0	7.5

a. Threshold to gate.
b. Gate to roll.

Improvement Option 8--Expand Passenger Terminal Building

To meet the demands of future traffic growth, the Airport has planned to expand the passenger terminal building so that additional aircraft parking positions and passenger processing facilities would be available. This expansion would entail construction of a southeast concourse. The number of aircraft parking positions would increase from 49 to 73 when the terminal expansion is completed.

The results of the simulation experiments are shown in Table 16. Taxiway congestion would be reduced if the terminal expansion was completed for the post-1985 period. This decrease is evidenced by the reduction in taxi-in delays for arrivals and taxi-out delays for departures. More importantly, with the existing terminal, the number of aircraft that have to be held and have to wait for a vacant gate is estimated to be seven with an average gate delay of 20.9 minutes per aircraft. With the terminal expansion, this gate delay would not occur, at least in the post-1985 period.

As demand increases to the level of that forecast for the post-1990 period, average taxi-in and taxi-out delays would increase to 0.4 and 1.5 minutes per aircraft, respectively. The results also show that two aircraft would be delayed because gate positions were not available, and the average gate congestion was estimated to be about 12.5 minutes per aircraft.

Table 16

EFFECTS OF TERMINAL EXPANSION ON TAXIWAY AND GATE CONGESTION
Lambert-St. Louis International Airport

Experiment No.	Description	Average taxiway delays (minutes) Taxi-in	Taxi-out	Gate congestion No. of aircraft held	Average gate delays (minutes)
35G	post-1985 Baseline	0.5	1.0	7	20.9
44	post-1985 Terminal	0.3	0.9	0	0
63	post-1990 Demand with expanded terminal	0.4	1.5	2	12.5